Electrochemical Treatment of Chlorinated Organics

K. Scott[1], H. Cheng[1] and P. A. Christensen[2]
1 Department of Chemical & Process Engineering
2 Department of Chemistry
University of Newcastle upon Tyne, NE1 7RU, England

This paper reports an experimental study of a process for the treatment of halogenated organic wastes and waste-waters using electrochemical reduction.

Halogenated liquid wastes are routinely produced by industrial processes at 1 million tonnes/year in the UK. Disposal to landfill is now virtually precluded by the Environment Agency. The incineration route has a number of serious defects, such as high capital costs of plant, processing and transport, production of the harmful substance dioxin, and the adverse public reaction. The ability to treat, and potentially to re-cycle, such halogenated organic compounds in the process will provide a significant economic advantage and will reduce the environmental burden. This work is aimed at assessing the feasibility of a process, based on electrochemical hydrodehalogenation (HDH), which will enable the recycling of the dehalogenated organic in a continuous process.

It was shown that the “chemical” dechlorination of DCP and PCP was not effective on reducing metals. Electrochemical dechlorination using metal cathodes was effective, with almost complete dechlorination possible at low concentrations of DCP and PCP. The use of electrocatalytic electrodes markedly improved the dechlorination efficiency.

Figs. 1 to 3 show typical data obtained for the electrodes in terms of linear sweep voltamogramms (Fig. 1), comparisons of chemical and electrochemical reduction (Fig. 2) and the extent of dechlorination (Fig. 3).

The HDH can be performed with solid polymer electrolyte (SPE) cells using both cation and anion exchange membranes. The use of an anion exchange membrane may be particularly useful when the simultaneous removal of chloride ion is desirable. The HDH of PCP and DCP can be achieved very efficiently using SPE electrolysis in the absence of supporting electrolyte. The performance of the supported cathodes in the flow cell was superior to that of the unsupported cathodes. For the low concentrations of organic treated, 1.0 mM, the current efficiencies were quite respectable, ca. 10%~70%. Energy consumption was reasonable: 6 and 21 kWh kg^{-1} for DCP and PCP respectively. Improvements in the catalyst, particularly in terms of increased surface area and optimisation of bonding should realise improved performance.

Product distribution obtained from HPLC measurements are comparable to results obtained from the chloride ion analysis. The HPLC results showed that there was virtually complete dechlorination of the chlorinated phenols. The process has also been successfully evaluated on a range of other halogenated compounds

References
1. DOE The Special Waste Regulations, 1996, HMSO London.

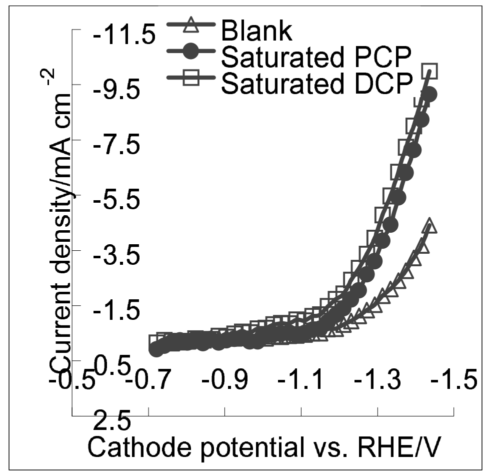

Figure 1. Linear sweep voltammograms of DCP and PCP in an H-cell with cathode A and Pt mesh anode. Catholyte: 0.05 M Na_2SO_4 (pH 3) solution without (blank) or with 0.071 mM PCP and 1 mM DCP.

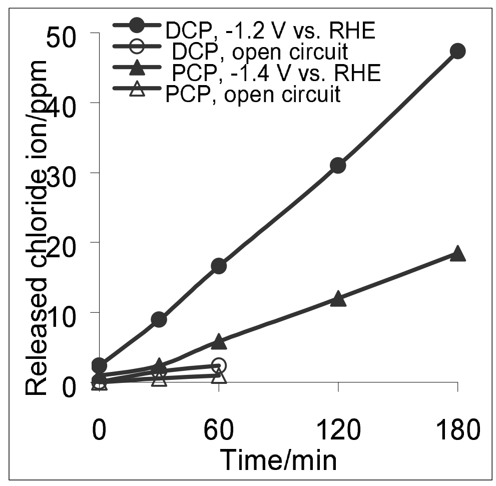

Figure 2. The relationship between the released chloride ion and reaction time for HDH of 1 mM PCP or 1 mM DCP+0.05 M Na_2SO_4 solutions in an H-cell with cathode B and Pt mesh anode at ambient temperature.

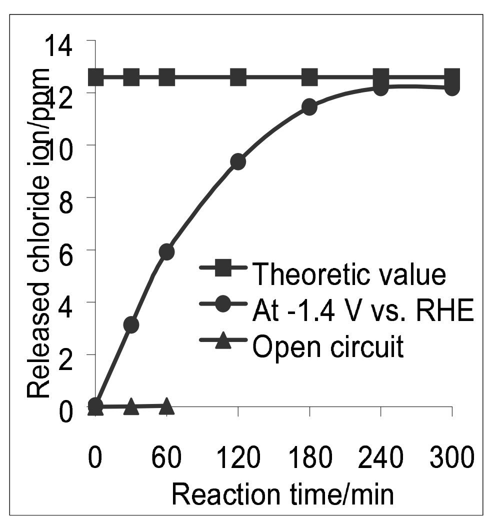

Figure 3. The relationship between the released chloride ion and reaction time for HDH of 0.071 mM PCP+0.05 M Na_2SO_4 solutions in an undivided cell with cathode C and the Nafion coated Pt mesh anode at -0.9 V vs. RHE and ambient temperature.